IMPROVEMENT OF THE MISSISSIPPI RIVER.

SPEECH

OF

HON. RANDALL L. GIBSON,

OF LOUISIANA,

IN THE

HOUSE OF REPRESENTATIVES,

FEBRUARY 5, 1879.

WASHINGTON.
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The House having under consideration the bill (H. R. No. 4318) to provide for th organization of the Mississippi River improvement commission, and for the correc tion, permanent location, and deepening of the channel and the improvement o the navigation of said Mississippi River, and the protection of its alluvial lands—

Mr. GIBSON said:

Mr. SPEAKER: I shall not attempt, at this stage of the discussion to do more than to state as briefly and as clearly as I can some of the reasons which should commend the bill reported from the committee on the improvement of the Mississippi River to the favorable consideration of this House, and to utter an emphatic protest against the amendment offered by the gentleman from Illinois, [Mr. SPARKS,] the effect of which would be fatal to every interest concerned. This measure constitutes a board of able military and civil engineers to make and complete a critical survey, not only hydrographical and hydrometrical, but topographical, of the river and its banks, and to take into consideration and test in the light of facts and science all theories that may be presented to them; and finally to report what, in their judgment, is the best plan for its improvement. Only partial surveys have hitherto been made, and every engineer engaged in the work has urged that such a commission should be appointed.

No river in the world presents phenomena so peculiar and extraordinary. It is not simply a great stream flowing to the sea, but it possesses ceaseless activity, is the architect of the continent, forever carrying on its work of destruction and reconstruction. The ablest investigators hold that it is three former rivers now united in one, that once forming a series of great lakes from the Ohio to the mouth of the Wisconsin, it cut through the chain of the Ozark Mountains and forced its passage to the Gulf of Mexico. At first a clear and limpid stream passing over mountain barriers and roaring cataracts, but finally having worn away the rocky strata which formed its bed, opened out into an inland sea, bringing down the body of the hills and mountains to build that vast region which surpasses in extent, in fertility, and productiveness any otherportion of our country, or indeed of the habitable globe, not excepting the valley of the Nile. Unlike other rivers it forms its own bed, it makes its own channel, it determines its own course, so that the country through which it flows is inseparably connected with the regimen of the river itself, and any plan for the improvement of its navigation would be faulty and imperfect unless it also embraced the treatment of its banks and the alluvial through which it passes.

But while the phenomena appear discordant and irreconcilable we know from analogy that they are controlled by and are obedient to fixed laws. This commission is established for the purpose of ascertaining these laws. When once fully understood we shall become masters of the forces to which all these phenomena are subordinate, and with this knowledge we shall be able to adopt a plan so comprehensive and satisfactory as to command universal support.

There are two distinct phenomena. At certain seasons of the year the water subsides, the channel is blocked up by snags and sand-bars, and for a great distance there is only four and a half to eight feet depth. This condition continues not for a few days or a few weeks but for several months during every year, interrupting trade and commerce and making its navigation difficult and perilous; the largest and costliest boats in which great sums are invested and that give employment to thousands of people, are compelled to be idle; the navigation of the river is almost as effectually closed as if artificial dams were built across its bed. The recent able report of Lieutenant Suter shows how serious and numerous these obstacles are.

Then, again, at other seasons the opposite condition prevails. On December 22, 1822, General S. Bernard and J. G. Totten submitted a report, after an examination of the river, to Major-General Macomb, in which they so accurately describe it in high water that I will quote from them:

> When the floods of the Mississippi have obtained their greatest elevation the whole valley through which it runs is submerged and presents a breadth of water in some places fifty or sixty miles. * * * While the waters of this river are over its banks, the operation of the current being in proportion to its elevation and consequent increase of velocity, *the changes which are produced in the bed of the river are great, sudden, and numerous.* Then are produced those multiplied turns and elbows which so strikingly characterize this great river, and which increase its channel to the double of what it would have been if the banks could have resisted its current. The corresponding concave parts of these turns are sometimes separated only by a very narrow neck, which being cut through by the waters, as often happens, present a new and navigable channel of perhaps a half mile in length in lieu of the old one of fifteen or twenty miles. The abandoned channel is entirely divided from the river except in floods, and on the west side, especially, becomes a lake.

This view has been confirmed by all subsequent observation and reports. A flood of this river through its alluvial region must not be confounded with its overflow in the highlands, or with a freshet in an upland stream. In both cases it is true property upon the banks is destroyed, crops, live stock, farming utensils, houses, the thrift and earnings of life's struggles, are swept away and the frugal and hard-working people are left in a pitiable and desolate condition; but when the Father of Waters swells into an inland sea fifty or sixty miles wide, covering the whole alluvial region, *the bed itself is often changed and its channel and course altered.* And in storms or at night there are no sheltering piers, no buoys, no light-houses for the shipping; they cannot be applied to these conditions so as to afford shelter or protection. Great boats propelled by steam are sometimes destroyed and often detained several days by the extraordinary obstacles they encounter; and smaller boats, barges and flat-boats, propelled by the current of the river itself, are absolutely at its mercy and are borne sometimes into the forests of the adjacent country and lost or whelmed and destroyed in the furious eddies and surging counter-currents. Navigation in such seasons is perilous, the cost of transportation is thereby increased, and insurance is doubled. It is with these two distinct and different phenomena of the Mississippi River that we are called upon to deal.

First, what can be done to remove the snags and bars that fill its channel in seasons of low water and to secure the necessary depth for the carrying trade of this great outlet.

Secondly, what can be done to improve the navigation in the high stages of the river; to render the channel permanent, and to afford shelter and security to the shipping, and to facilitate trade and commerce. These are plain, practical propositions.

An opinion prevails that when you come to apply the constitutional power to regulate commerce to rivers, all you can do is to deepen their channels or to overcome obstacles by building canals around them. Thus Congress appropriated four and one-half millions to build a canal around the Des Moines Rapids—a sum sufficient nearly for the improvemeot of the Lower Mississippi. But it will not do to regard the Mississippi as an ordinary river; it is in fact an inland sea, and its relations to the Constitution are analogous to those of the lakes and the sea-coast. The first act passed by the Federal Government under the power to regulate commerce was not to deepen or widen channels—there was plenty of water on the Atlantic sea-board—but it was for the establishment and support of light-houses, beacons, buoys, and public piers, to guide in safety the mariner on his voyage against the dangers of capes, reefs, and shoals, and to point out the best and safest channel; in fact, to indicate the channel. Our coasts have been studded with such aids to navigation and commerce; we have constructed public piers, including harbors for protection where vessels might take shelter in storms. In all these instances it was not to secure deep water, but, in the language of the acts themselves, it was to render navigation "easy and safe."

It is true that when the Constitution was made its framers had in contemplation the Atlantic coast only. A very small portion of our population had passed into the valley of the Mississippi, and none had reached the lakes. There was not a State wholly within the valley; the greater part of it, including the whole of its right bank and all on both banks below the thirty-first parallel, belonged to Spain, who claimed the exclusive right to navigate the river to the south of it, and a right in common with us to the residue. Steam had not then been applied to navigation, but the principles laid down in the Constitution are not confined to particular cases but are broad, general, and comprehensive. It cannot be held now that we have the power to expend millions upon millions for the benefit of the trade and the commerce on our ocean fronts, lakes, and rivers in the uplands, but have not the power to do anything for the benefit of the people living upon the borders of the Mississippi River because its conditions are different and peculiar.

The tonnage built last year on the Mississippi River and its tributaries was 460 vessels, 68,928 tons: on the lakes 101 vessels, 11,438 tons; and on the Atlantic and Pacific seaboard 697 vessels, 155,138 tons.

The carrying trade upon this great internal artery and its tributaries exceeds our whole foreign trade, and is rapidly increasing, so that within a few years it shall surpass all other avenues of commerce in the country put together. It was acquired by treaty and paid for out of the common treasure of the people of the whole country; it was dedicated, not only by the terms of the treaty but by the conditions of the bills for the admission of the riparian States, to the untaxed and free enjoyment of the people of the country, so that in every sense the Mississippi River is a national highway. The States

bordering upon it can exercise no jurisdiction over it. Chief-Justice Taney says, in The propeller Genesee Chief *et al. vs.* Fitzhugh *et al.*:

In regard to the power to regulate commerce "the admiralty and maritime jurisdiction granted to the Federal Government by the Constitution of the United States is not limited to tide-waters, but extends to all public navigable lakes or rivers where commerce is carried on between different States or with a foreign nation. There were no navigable waters upon which commerce was carried on except tide-water until the valley of the Mississippi was settled and cultivated and steamboats invented."

As to the limitation of maritime jurisdiction by the tide-water in England he says:

This definition in England was a sound and reasonable one, because there was no navigable stream in the country beyond the ebb and flow of the tide.

Whether we consider, therefore, the magnitude of the interest involved, or the political aspects of the question, or the decision of the Supreme Court, it is clear that the power to regulate commerce applies with as full force to the Mississippi River, and to the construction of the proper appliances to give it a permanent channel and deep water, and to afford protection and shelter, "*to secure ease and safety*," in the language of the old acts, and facilities to its trade and commerce, as to the lakes and seaboard. And if it can be shown that levees and dikes and jetties are as essential to accomplish these beneficent purposes as water-gaps and sheltering-piers, why should not the Federal Government undertake their construction?

We have listened in the course of this debate to able and strenuous advocates of the outlet theory. The honorable member from Texas [Mr. REAGAN] insists that it should be examined; the veteran member from Massachusetts, [Mr. BANKS,] who has spoken with a patriotism as broad as his country, also insists that this view should be thoroughly considered. I cordially concur in this opinion. Let the friends of this plan be heard, as I have no doubt they will be with great respect, by the commission. Others advocate the plan of making immense reservoirs in the mountainous regions in which the waters shall be confined so as to prevent an excess or a scarcity in the river. This was the favorite plan of the Emperor Napoleon for the treatment of the river Rhone. Others again insist that the best plan is to confine the water to a narrow channel where it is unduly extended and shallow by jetties, where they can be applied, or by levees where they cannot be applied. A jetty is a levee in the popular sense of the word within the bed or channel of the river, while a levee is a jetty on the bank of the stream. This plan rests upon the theory that in sedimentary rivers, in the Mississippi particularly, as the water is confined the velocity and depth is increased and the surface lowered, and that thus two great objects may be accomplished by one and the same method, namely, "ease and safety" to navigation and protection to the industrious people on its banks from the dreaded floods. The amendment of the gentleman from Illinois [Mr. SPARKS] would exclude from the consideration of the commission this theory. It appears to me that if we are to have a commission at all it should be left free and uninstructed; it should be permitted to take into consideration all plans, all theories, and to report to us the one that they may agree upon as the best to accomplish the purpose we have in view.

I have already stated that the conditions of the Mississippi River are novel and difficult, and that no complete survey has ever been made to the satisfaction of the engineers who have been engaged in the examination of that river. Let us, therefore, not hamper the

commission about to be appointed by any instructions or views of our own, but afford them every facility in the great work of ascertaining the laws which control the river. We have before us the report of a board of engineers appointed to examine the jetties at one of the passes of the Mississippi River, dated January 20, 1879. This report furnishes ample food for reflection; it declares that the plan of Eads has passed from the field of experiment to a practical success. Upon what is this plan based? It simply runs out two parallel levees or jetties, like sheltering piers, from the mouth of South Pass over the bar into the Gulf, thus compelling the water into a narrower channel, and the result has been that the increased velocity of the current has scoured away the bar and given to the Mississippi Valley an open and unimpeded mouth to the sea.

In the month of January last a convention of the leading men connected with agriculture, commerce, and manufactures in the Mississippi Valley, assembled in New Orleans and passed a formal resolution declaring that the experiment which had secured deep water at the mouth of the river had more than repaid the cost of it within a single year by the benefits it had conferred upon the vast interests they represented, notwithstanding the deplorable calamity of the epidemic.

Now, what I desire to call attention to is the fact that the principle upon which the jetties are constructed is precisely the principle upon which the levee system rests. I hold that we cannot resist the momentum of the great river at its flood height or alter its regimen, but that by directing the forces which control it we may compel it to do the work essential to the improvement of its navigation and to the protection of the people dwelling upon its banks; that these forces may be utilized, not by dispersion, but by concentrating them by levees, in special directions and to effect particular purposes. Wherever the river is narrow all the engineers are agreed that there is deep water and no caving of the banks, and wherever the river is divided by islands or its channel is unduly wide, there you will find sand-bars and shallow water, and whenever a crevasse occurs or an outlet is made the current is checked, the channel is filled with sediment, and the surface of the river elevated.

In the earliest report ever made, that of Generals Bernard and Totten, on December 22, 1822, they declare—

> The only means which appear practicable to us, is the construction of dikes—they operate by diminishing the current above them, thus economizing the expanse of water, at the same time constraining the current to rush with greater velocity through the narrow spaces *to be deepened*.

George W. R. Bayley, a distinguished engineer, long a resident of Louisiana and a close and accurate observer, says:

> The tendency of the levee system is to reduce instead of to elevate the river flood-line. A perfected levee system would tend to lessen the danger of inundations; the river channel would be accommodated to its necessities, and the danger or liability reduced to its minimum.
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> The action of water in slowly wearing channels thousands of feet deep through even the hardest primitive and volcanic rocks—as, for instance, through the immense cañons of Colorado—is too well known to be questioned. It is also so well known as to make denial useless that the action of the powerful Mississippi current upon the hard blue clay (whether alluvial or tertiary is not essential) which forms its bed, though comparatively slow as respects its action upon other strata, is sufficiently rapid to allow for and keep pace with the increase required for the gradual extensions of the levee system and the closure of the outlets.
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> All experience and observation show that where the Mississippi River current is checked from any cause and at any stage, but more especially when the river is

falling, then a portion of the earthy matter held in suspension is dropped, and the more heavily charged the water is the greater the deposit.

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The same laws govern in all sedimentary rivers, whether small or great. The first effect of an outlet is to lower the flood-line of a river, because time is required for readjustment of the river's regimen; but the ultimate effect will be the reverse, because the law is that the less the quantity of water flowing the greater is the slope required for its discharge at a given velocity.

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It is certain that all sedimentary rivers adapt themselves to every change in their regimen. The Mississippi is no exception, notwithstanding that its vast magnitude makes even slight changes in it, as work of time. Its floods can be controlled by means of a levee system, but only the National Government is able to perfect and maintain such.

Outlets are worse than useless, * * * Reservoirs are impracticable. As to diversion of tributaries, it would be useless, if practicable. Levees can most certainly be relied upon, and the object of this paper has been to demonstrate that levees alone are needed; that the only way to reduce the flood-line is to perfect the levee system.

In this opinion Professor Charles G. Forshey concurs, whose scientific ability and attainments are unsurpassed and whose practical knowledge of the river is unequaled. And there cannot be found a captain of a steamboat acquainted with the river by constant observation through a long series of years, or a resident upon its banks, who does not entertain this view. He says:

We conclude, what we should have inferred from hydrology, that the effect of confining the waters in the channel is not to raise, *but to depress the level.*

General J. G. Barnard, in a paper published in July, 1850, says:

It is pretty well established that certain relations exist between the configuration of the bed of a stream and the velocity of its current. This relation is the more discernable and capable of being subjected to calculation in rivers whose beds have been formed of materials brought down by their own currents; in other words, which have made and shaped their beds. If, from any cause, such as throwing off a portion of the water through a water-weir, the velocity of the current is diminished, it is no longer able to maintain its sediment in suspension, but will continue to deposit it in its channel until, through the elevation of its bed, its velocity again becomes what it was before it was disturbed, sufficient to maintain its sediment in permanent suspension. Now, it is a well-established principle in hydro-dynamics that the less the volume of water the greater the surface-slope required in order to maintain a given velocity.

Guglielmini laid down the same doctrine, when he declared that—

The greater the quantity of water that a river carries, the less will be its fall—that the greater the force of the stream, the less will be the slope of its bed.

These principles were observed and illustrated in the treatment of the Po, the Danube, and the Rhine. The traveler is filled with admiration at the results accomplished in the lovely valley of the Rhine. Where a few years ago was shallow water and vast tracts of country uncultivated and liable to overflow, you will now find excellent navigation and broad fields covered with vineyards, and the homes of a prosperous population. But in no country has the science of engineering won such complete mastery over the flow of waters as in Holland, or wrested both from rivers and the ocean, such areas of fertile land and secured, such admirable highways.

I am sure that the gentleman from Illinois, [Mr. SPARKS,] if it be shown to his satisfaction that levees and jetties are to the trade and commerce on this great river what light-houses, water-gaps, and sheltering-piers are on the lakes and ocean fronts, will not hesitate to vote an appropriation for their construction. A recent report of the leading engineers of the Army declares in effect that the improvement of the navigation of the river and protection of the

country by levees are interdependent. I beg leave to call the attention of the House to a brief extract from this report:

> The great obstacle to the improvement of the low-water navigation and to maintaining a levee system is one and the same for both, namely, the instability of the river from the caving of its banks. When this can be overcome by means not inordinately expensive (on which point we have treated more fully in our preliminary report on the subject of low-water navigation of the river) we may expect a deepened channel, a lowered high-water surface, and a stable river, the margins of which shall be securely cultivated, to the enormous development of the wealth and population of the region. *We believe, therefore, that the levee system, if undertaken, should be matured and developed in connection with the navigation improvement.*

I will not, Mr. Speaker, tax the forbearance of the House any longer. I shall ask to append to these remarks the report of the engineers from which I have quoted, and my own letter upon this subject, as well as some views of Mr. Eads and of General Beauregard. No authorities could be introduced to this House with stronger titles to your confidence than General Beauregard or Captain Eads, or those from whom I have quoted, all of whom unite to scientific attainments of the highest order much practical experience.

It is said, Mr. Speaker, by Reclus, in his work on the Earth, that the Amazon is the glory of the planet. I admit that this is true when we contemplate alone the majestic flow of its waters; but no man can dispute the supremacy of the Mississippi as a river of commerce. And there is but one Mississippi Valley on the globe. It is soon to be not only the main seat of our agriculture, but of our political empire. You may deny to the people of that valley to-day their just claims for the improvement of their great highway. You can but defer this beneficent work, for in the course of a few years the representatives of the Valley will not be here to petition but to control the legislation of the country.

Why should you not improve the Mississippi? It belongs to no State; it cannot be monopolized; it is beyond the reach of corporations; it is the Nation's free highway; it is the natural outlet of a mighty valley fifteen hundred miles wide and two thousand miles long, the richest and largest in the world, penetrated by fifty thousand miles of boatable streams; it affords the cheapest navigation known, furnishing itself propelling power; a single steam-tug with barges will bring down more wheat than can be moved on fifteen hundred freight cars, and at half the cost. If the adjacent States could tax the tonnage upon its waters only as large as New York taxes the traffic on the Erie canal, the tax would yield ten times the sum every year required for its permanent improvement. It is the common property of all the people and their security against the railway corporations which absorb their profits and consume their substance.

We gather in population from all parts of the earth the restless, active, and vigorous, bringing their peculiar theories of religion, government, property, and social science, elements often of disorder and anarchy, menacing the stability and peace of society; but the stream of American life and civilization flows on, sometimes turbid, sometimes lashed into fury, exciting apprehension and alarm, but fenced in by the invincible barriers of the Constitution and laws—bears along, for the benefit of the present and of coming generations, these priceless institutions that combine freedom and order, liberty and law.

So the Father of Waters, gathering force and volume from countless tribute streams, now sweeps away, with its uncontrolled floods, the toil of generations, and baffles man's enterprise, hopes, and destiny; but, once made obedient to the genius of American engineer-

ing, it shall bear upon its bosom, in security and safety, the wealth and fortunes of the mightiest empire on the earth, and distribute benefits and blessings only to the teeming millions upon its shores and to every part of the habitable globe.

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WASHINGTON, *November* 17, 1878.

SIR: The *supplemental instructions* of General Humphreys, the Chief of Engineers, *issued on the 13th instant to the board of engineers* for the improvement of the Mississippi River, *invite you* "to the consideration of the effect of a permanent levee system throughout the length of the river below the mouth of the Ohio, not only upon its low-water navigation, *but also of the benefits* it would confer in affording *protection and giving needed facilities to shipping, commerce, and* navigation in the high stages of the river." The Constitution provides (article 1, section 8) that "Congress shall have power to regulate commerce with foreign nations, and among the several States, and *with the Indian tribes.*" *That the grant of power over commerce is complete and absolute should not excite surprise when we reflect that* it was mainly the object which led to the formation of the Federal Constitution. The first step was taken by Virginia on January 21, 1786, when she submitted to her sister States a formal proposition for the appointment of commissioners by each "to take into consideration the trade of the United States." And within one month after the Federal Government went into operation under the Constitution the First Congress passed "an act for the establishment and support of light-houses, beacons, buoys, and public piers," the object being, as recited in it, "to render navigation easy and safe."

At the outset there was some dispute among public men as to whether this power might be applied to internal improvements generally, but there never has been a doubt as to the unlimited jurisdiction of the Federal Government over commerce and of its power to legislate for its benefit. For half a century there has been a decided concurrence of the views of the ablest American statesmen on this subject, and the Government has expended large sums with the best possible results. Mr. Webster says: "Over whatever other interests of the country this Government may diffuse its benefits and its blessings, it will always be true as matter of historical fact that it had its origin in the necessities of commerce, and for its immediate object the relief of those necessities by removing their causes and by establishing a uniform and steady system." Mr. Calhoun says: "These provisions furnish conclusive proof that the object of the power was the increased safety and facility of commerce." President Jackson says: "The practice of defraying out of the Treasury the expenses incurred by the establishment and support of light-houses, beacons, buoys, and public piers within the bays, inlets, and harbors, and ports of the United States, to render the navigation thereof safe and easy, is coeval with the adoption of the Constitution, and has been continued without interruption or dispute."

It may now be regarded as the fixed policy of the Government, sanctioned by our ablest statesmen and made operative upon a large scale at every session of Congress, to protect and aid and facilitate commerce in every possible manner. The methods by which this may be done upon our ocean and lake fronts, and even upon the rivers in the uplands, have caused but little difference of opinion. Estimates and surveys have been made with regularity, and Congress has appropri-

ated large sums for their prompt and complete execution. Fortunately, there has been a happy concurrence between the engineers of the Government and the law-making power. Nearly $9,000,000, authorized to be expended under the direction of the War Department for the benefit of our commerce, for the improvement of our rivers and harbors, was voted at the last session of the present Congress. It is proposed now to expend nearly $2,000,000 upon Harlem or East River, lying wholly within the State of New York, in addition to the large amount appropriated for the harbor of that great metropolis. But while the Government is making these large expenditures with unstinted liberality for the commerce and trade on our ocean fronts and lakes and rivers in the uplands, not a dollar, in comparison, has been devoted to giving "ease or safety" or needed facilities to the commerce and trade upon that great inland sea from Cairo to the head of the passes—the highway fed by fifteen thousand miles of navigable streams, and bearing upon its bosom the commodities of eighteen States and twenty millions of people—the natural artery and outlet for the empire of the great Northwest. Why is this? It is simply because the Government has failed to appreciate the necessities of this river and of the valley of the Mississippi. The moment the engineers agree as to the usefulness of levees, Congress, I believe, will vote the sums necessary for its improvement.

The question therefore submitted for your board to determine, for the time being at least, is whether anything can be done in the direction indicated. You will observe that you are not requested to make any surveys or estimates. Many surveys and estimates for levees have already been made by distinguished engineers. What is needed now is your opinion as to whether levees will not subserve the commerce and trade upon the Mississippi River—are not, in fact, the proper and essential appliances to make its navigation "easy and safe," and will not render "needed facilities for shipping, commerce, and navigation in the high stages of the river." They would unquestionably prevent overflows. It is agreed by all engineers that overflows destroy the channel, or rather change it, so that, when the water subsides, it is difficult to ascertain the outline of the new channel; sandbars are formed and snags are deposited, so that the liability to accident and the dangers of navigation are greatly increased. An enormous tax is imposed upon the carriers of commodities in the higher rates of insurance, and in the necessities for more powerful machinery and boats, and in their frequent loss. It is estimated that the extra insurance alone amounts to not less than $10,000,000 annually, a sum sufficient to make all the needed improvements.

The levees confine the water to its channel, and indicate better than light-houses or beacons or buoys precisely where it is. But it must be borne in mind that much of the commerce and trade upon this river might be carried without the expense of steam. Before the destruction of the levees a vast business was done in flats and barges, for the current itself furnishes the propelling power. The people living upon the banks purchased their supplies, from silk dresses and pianos to plows and wagons, their clothing, their groceries, their farming utensils and household goods, from the trading-boats, and fleets of these boats were seen in all the bayous and at every village and city. Of the single article of coal, millions of dollars' worth is shipped from Pittsburgh alone. Now, when the river is thirty or forty or fifty miles wide, an ocean torrent sweeping everything to destruction, what protection is there for this, the very commerce for which that great river should afford facilities, a commerce without any expensive vehicles,

between the producer and consumer direct? The great West is seeking the markets of the world for her grain; but, while producing fabulous crops, the profits are so cut down or off by the cost of transportation that the people of that favored section, in the midst of an abounding land, are crying out for relief. Afford proper security by levees to the shipping, and barges and flats would carry their products half way to the European markets without loss, and at one-half the cost now exacted. In a very few years one hundred million bushels of western wheat will seek this route to the sea. It may be transported now at eight or nine cents per bushel, but with proper facilities the cost might be reduced to three or four cents, a saving of itself sufficient to bring comfort and wealth to the producers. The proposition I desire to submit is this: Levees establish the proper instruments to protect commerce and trade on the Mississippi River; they are continuous harbors or sheltering-piers; they are adapted to give the protection and facilities needed; they are the very "counters" along which the producers of the West and the people on the banks of the river make their exchanges. We do not ask for millions of dollars for the harbors at Memphis, Vicksburgh, Natchez, Baton Rouge, and New Orleans; such expenditure is not needed as upon the lakes and sea-coast. We do not ask for an appropriation of millions to dredge out or blast out the channel, or to build dams or canals around rapids, as in the uplands. The Lower Mississippi requires different treatment. But that is no reason why it should receive none at all. The cost of these works, in proportion to the commerce and trade to be benefited, is insignificant. A tax of less than 1 per cent. upon the tonnage on the river would complete them in a short time. The river itself furnishes the propelling power to every keel launched upon it. Not a single man-of-war, not a sailor or soldier, is required to protect the flag, as upon the ocean, from its headwaters to its mouth. The vast trade and commerce of the Mississippi Valley would be our reliance in war as it is in peace, beyond the reach of any enemy, and taxing the people of the country not a dollar for a navy to protect it.

It has been suggested that the States should agree among themselves, and devise a uniform and general system for the improvement of the river. It is evident that there should be uniformity, for if the levees were erected along the entire front of Louisiana, and Arkansas should not co-operate, they would be swept away in a single season of high water. Yet there can be no agreement among the States, for the Constitution declares, "No State shall, without the consent of Congress, *lay any duty of tonnage*, keep troops, or ships of war in time of peace, *enter into any agreement or compact with another State.*" Anything short of a uniform and general system would be incomplete and useless. It is clear that unless the General Government undertakes the work it cannot be accomplished. It is for the board of engineers to decide the question. The Federal Government has full jurisdiction over the river; it was acquired by treaty, and it is owned by the Government. The fact that the levees would confine the water to its channel and thus prevent the overflow of its banks and the destruction and depopulation of the delta, strange as it may seem, is urged rather as a reason why the Federal Government should do nothing for the protection of the commerce and trade on the river. It is true that the levees would afford security to the people of the valley against the invasions of the river, and that an area of territory greater in extent than some of the States of this Union, surpassing any portion of our country in fertility and in the

capacity to produce the great staples of corn, cotton, sugar, and rice, would be brought into cultivation and afford occupations and homes to millions of inhabitants.

General Abbot, United States Engineers, says: "The total area of the bottom lands is about thirty-two thousand square miles, of which a mere narrow strip along the main stream and its principal tributaries and bayous has been heretofore open to cultivation. Protected against the river and properly drained, this would render available at least two million five hundred thousand acres of sugar land, or more than double the amount heretofore planted; about seven million acres of the best cotton land in the world, capable of yielding a bale to the acre; and not less than one million acres of corn land of unsurpassed and inexhaustible fertility." The magnitude of the interests involved may be held to concern the whole country, and if the "general-welfare clause" of the Constitution can be invoked at all, surely it would apply here. Yet it cannot be that these considerations can have weight against the proper claims of trade and shipping and navigation. On the contrary, it may be urged with justice that the Federal Government, claiming and exercising control over the river as a great national highway, should regulate it so as not to injure the people living upon its banks—a people powerless, individually or as States, to exercise any jurisdiction over the river. All jurisdiction is forbidden to the States.

The very means which the adjacent States might employ in order to establish a uniform and complete system of levees are denied to them by the Federal Constitution. They can neither co-operate nor exercise their power over the subject when co-operation and joint jurisdiction are absolutely indispensable. The river is the property of the National Government, held for the benefit of the whole country. The ownership is unquestioned, complete, and absolute. The doctrine that the owners of property should so use it as not to injure that of others is of universal application. *Sic utere tuo ut non alienum lædas* is a legal maxim familiar to all jurists and publicists, and held to be binding upon governments as well as individuals. It is clearly within the constitutional power and duty of the Government, as well as promotive of the interest of the people of the whole country, that these vast regions should be protected from the devastations of the river by a uniform system of levees. We have bought vast tracts of country and conquered others in expensive wars. Why may we not bring the delta of the Mississippi within occupancy and settlement? It is true that a system of levees would not only give security against inundations that are destructive alike to the channel and navigation and trade upon the river and to the industrious people cultivating the soil in the valley, but that it would form the most effective barrier against disease—epidemics equally fatal to the health of the country. But these views are foreign to the purpose of this communication. I desire now to speak altogether in the interest of commerce and trade, the navigation and shipping upon the river, and the means for benefiting and improving them.

I have forborne to weary you with any statements of facts showing the vast interests involved. You are familiar with the resources of the mighty valley. Nor have I ventured to urge upon you any theory for the treatment of the river. I beg, however, in conclusion, to invite your attention to the following extract from a report made by those distinguished statesmen, James Gadsden and James Guthrie, after a full investigation of the whole subject in 1845, and submitted to Congress, with his approval, by John C. Calhoun: "Intimately

connected with this subject is the improvement of the navigation of the Mississippi. The science of the engineer has been bewildered on the subject of the improvement of rivers. Those free from rock, and which, like the Mississippi, course through alluvial formations, inundating their banks, depositing and making the very soil through which they cut, are uncontrollable and most difficult of improvement. A great engineer in England, when substituting a canal for a river, is known to have exclaimed in explanation that 'rivers were made to feed canals.' The expenditures on the Mississippi thus far, if reports are to be credited, have produced no results corresponding to the vast sums appropriated. When the channel has been straightened at one point it has been lengthened at another, and obstructions or deposits in one bend have only been transferred in their removal to another. 'Sawyers' and 'planters' have in one season been reduced in number to be replaced by the succeeding one.

The only fact clearly established, and it is one to which attention should be particularly directed as bearing with peculiar influence on the proposition submitted, is that where the banks of the Mississippi have been leveed and prevented from inundating the swamps the spring rises are scarcely perceptible, and the surplus waters are discharged *by deepening the bed;* its current no longer able to rise and expand over a wider surface, they have to deepen the bed to furnish vent for the waters to be discharged. The reclaiming, therefore, the swamps and confining the river to its bed will deepen it, and do more to preserve unimpaired the navigation of the Mississippi than all the projects which have hitherto been devised or acted on for its improvement. The suggestion, however, is worthy of examination, and it is the stronger recommended as it may accomplish a great object at comparatively little cost. The swamps of the Mississippi, now worthless, and made so by the inundations of that river, may be made, by their own reclamation, the instruments of improving the navigation of that stream." I have laid these views before you on account of the urgency of the case, and with the hope that you might be induced to take immediate action and give the country the benefit of your opinions without delay.

R. L. GIBSON,
Member of Congress from Louisiana.

General J. G. BARNARD,
Corps of Engineers, New York City.

IMPROVEMENT OF THE NAVIGATION OF THE LOWER MISSISSIPPI RIVER.

Letter from the Secretary of War, transmitting report of the board of engineers upon the improvement of the low-water navigation of the Mississippi River below Cairo, Illinois.

WAR DEPARTMENT,
Washington City, January 27, 1879.

The SPEAKER *of the House of Representatives:*

The Secretary of War has the honor to transmit to the House of Representatives, for the information of the Committee on Commerce, a letter from the Chief of Engineers dated the 27th instant, and copy of report of the board of engineers on the improvement of the low-water navigation of the Mississippi River below Cairo, Illinois.

GEO. W. MCCRARY,
Secretary of War.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 27, 1879.

SIR: I have the honor to submit the inclosed copy of the report of the board of engineers on the improvement of the low-water navigation of the Mississippi River

below Cairo, Illinois, upon the "effect of a permanent levee system throughout the length of the river below the mouth of the Ohio, not only upon its low-water navigation, but also of the benefits it would confer in affording protection and giving needed facilities to shipping, commerce, and navigation in the high stages of the river;" and beg leave to invite attention thereto.

I concur in the views and conclusions of the board, and, in view of the importance of the subject, respectfully suggest that the report be sent to the Speaker of the House of Representatives for the information of the Committee on Commerce.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. GEORGE W. MCCRARY,
Secretary of War.

Effect of a permanent levee system on the Mississippi below the mouth of the Ohio River.

ARMY BUILDING, *New York, January* 25, 1879.

GENERAL: In reply to your letter of November 13, 1878, which invites "the attention of the board of engineers for the improvement of the low-water navigation of the Mississippi River to the consideration of the effect of a permanent levee system throughout the length of the river below the mouth of the Ohio, not only upon its low-water navigation, but also of the benefits it would confer in affording protection and giving needed facilities to shipping, commerce, and navigation in the high stages of the river," the board have the honor to report their views as follows:

The letter presents the matter of the effects of a levee system in two aspects—

1. Its effects on low-water navigation.

2. The benefits it would confer in affording protection and giving needed facilities to shipping, commerce, and navigation in the high stages of the river.

In both these points of view it is referred to by Hon. R. L. Gibson, M. C. from Louisiana, in his published letter to the president of the board, a copy of which is appended, (marked A;) but while asserting strongly the benefits to be conferred by a complete levee system on low-water navigation, he is especially strenuous and elaborate in his expressions concerning the benefits to be realized at high-water stages, for which stages, indeed, the levees, as hitherto designed, have exclusive reference. But this exclusive reference has been to protection of the lands from overflow. As "affording protection and giving needed facilities for shipping, commerce, and navigation," the levees have not been hitherto constructed, demanded, or projected.

To deal with the question whether there is any connection between levees and "facilities for shipping, commerce, and navigation" at high stages we refer to the actual condition of things. We find that throughout all the extension of the Mississippi along which the levee system is practically efficient, and where the marginal lands are generally cleared and cultivated, the levees have been an important aid to commerce. Below the mouth of the Arkansas and as far down as the forts below New Orleans the levees have been long enough in existence to give evidence of their effects, direct and indirect. Immediately behind them are the cultivated lands, the plantations, whence come sugar, cotton, and other valuable staples. To each one of these plantations not only is the levee the protecting agent which renders their cultivation practicable, but it is during floods the landing place of the steamers, barges, or flat-boats which bring their supplies and carry their productions away.

The levees thus become aids to commerce with the cultivated regions directly along the margins of the river; moreover, they allow the maintenance, which would otherwise to some extent be impracticable, of the numerous common roads leading back to, and bringing in the productions of, regions considerably removed. Railroads, of which there are several, which, to cross the Mississippi or to reach its marginal cities, pass through the extensive swamp regions bordering the river, can only secure an unimpeded traffic during floods by raising their tracks above the level of the great floods, or by the protection of levees.

Our information does not justify us in maintaining that levees would have so important an influence as claimed in promoting flat-boat navigation, though, doubtless, were the channel of the river regulated to a nearly uniform width, high-water outlets closed, and bank-overflow prevented, flat-boat as well as all other kinds of navigation (flat-boat more particularly) would be rendered easier, more rapid, and safer, but such a channel regulation involves, as will be shown, something more than levees. Flat-boat navigation was formerly more important than now, and when levees above the mouth of the Arkansas were not in existence.

This kind of navigation has yielded to the superior facilities offered by the barge system and by the introduction of large freight-carrying steamers. Most of the flat-boats now seen on the river come out of the Ohio and its tributaries, and are

most numerous about the time of the fall rise, a rise which never amounts to a "flood;" hence, at a stage in which the natural banks bound and furnish visible margins to the navigation channel.

In the lower river, through the regions where the margins are under cultivation, the levees are generally laid close to these margins, and afford, as has already been stated, useful facilities to commerce in making practicable the coming alongside of steamers and the receiving the products of the plantations and discharging freights for the use of the same, or for the back country. In ordinary rises the natural banks are not overflowed, but when that happens in "flood" years they serve a purpose in still defining the channel.

Above Vicksburgh the caving of the banks and the general instability of the river are greater. To escape the inroads of bank-caving, and sometimes to cut off very elongated bends, the levees are often at considerable distance from the banks. In such cases they may not be seen at all from the river, or, if visible, would serve no useful purpose in defining the channel. They have not yet, indeed, throughout the upper portions of this section, been long enough and permanently enough maintained in existence to inspire confidence and give rise to a systematic cultivation of the marginal lands.

To sum up: the levees, where they have been permanently established, do, to a certain extent, afford protection and give needed facilities to commerce and navigation, and were they permanently established throughout the river, they would doubtless develop a large additional commerce and afford the kind of facilities just mentioned for its transaction.

2. *The effect of levees on low-water navigation.*

Levees have no direct action except when the water is high. Nevertheless, a connected levee system begins to act before the stage of actual bank overflow of the Mississippi is reached. The numerous creeks, or bayous, which partially drain the great swamp basins of the Saint Francis, Yazoo, and Tensas furnish inlets through which the water of the river begins to flood the swamps, even when several feet below the elevation of its natural banks. The levee system would therefore come into useful action before the natural banks were overtopped. And this would be the more usual extent of its action, for the "flood" years are on average but one out of four or five.

That the confining of this usually escaping water in one channel, in ordinary as well as in flood years, would, in a general way, tend to deepen the bed, we do not doubt. But where the low-water navigation is bad it is not because there has been a lack of water at high stages. It is because of inordinate width at those places, over which the river sweeps with no well-defined channel, or with channels shifting with different stages of the river and with different years.

From whatever cause this widening has had its origin, the result is the same—a shoal, or "bar," or bad low-water navigation. In most cases this inordinate widening seems obviously due to rapid caving away of the concave banks in the bends; in some cases great width is found between straight banks, suggesting (possibly) in the locality an unusually tough and unyielding bottom material. In general, however, the bottom material of these bars or places of bad low-water navigation is shifting sand or gravel. For more particular description of bar formation, growth, and movement, we refer to Major Suter's report "upon the improvement of the navigation of the Mississippi River between the month of the Ohio and New Orleans." (Executive Document 19, part 7, Senate, Forty-third Congress, second session,) made in response to the call of the Senate Select Committee on Transportation Routes. In this report there are enumerated forty-three localities where less than ten feet low-water channel depth may be found, and thirteen where there may at times occur less than five feet. Elsewhere the navigation was good. Hence the improving of the low-water navigation of the Mississippi below Cairo consists mainly in the removal of these bars, or the excavation and the maintaining through them of channels of adequate depth and width. A glance at the sketches of the localities accompanying Major Suter's report, and especially of those of worst low-water navigation, as for instance the Plum Point Bars, is sufficient to show that levees, in the ordinary sense of the word, even if they come into action every high-water stage instead of only every "flood," would have little or no influence on the low-water navigation. They would leave to the river its inordinately great width and area of shifting sands, and exert little or no influence on channel formation. This would be the fact even if they everywhere followed closely the natural banks or margins of the ordinary high-water flow. But, as has already been remarked, the present system of levees, as actually built up to and above the mouth of the Ohio, though now in a very ruinous condition, in its upper portions deviates not infrequently from the immediate banks to cut across bends or avoid the invasion of caving banks. In the more elaborate levee system designed by the commission of 1874, the great levees are laid, for the upper portions of the river, at greater or less distance from the immediate margins; and though an auxiliary system more

closely following the banks is contemplated, the latter, like the present levees, must depart from the banks at many localities to avoid early destruction from caving.

On the other hand, closely adhering levees which in all high stages, whether of ordinary rises or "floods," shall confine the water which now escapes into the swamps, would, by an increased current action, accelerate the caving of bank in the bends and enhance the instability of bed which now not only makes the work of navigation improvement so difficult, but is one of the most formidable foes to a permanent levee system. To the caving of banks is also due the snags, which form such serious obstructions to the navigation of the river.

The great obstacle to the improvement of the low-water navigation and to maintaining a levee system is one and the same for both, namely, the instability of the river from the caving of its banks. When this can be overcome by means not inordinately expensive (on which point we have treated more fully in our preliminary report on the subject of low-water navigation of the river) we may expect a deepened channel, a lowered high-water surface, and a stable river, the margins of which shall be securely cultivated, to the enormous development of the wealth and population of the region. We believe, therefore, that the levee system, if undertaken, should be matured and developed in connection with the navigation improvement.

Other and imperative duties of individual members have made impossible an earlier convention of the board for the consideration of this subject.

Respectfully submitted.

J. G. BARNARD,
Colonel of Engineers and Bvt. Maj. Gen., U. S. A.
Z. B. TOWER,
Colonel of Engineers and Bvt. Maj. Gen., U. S. A.
H. G. WRIGHT,
Lieut. Col. of Engineers and Bvt. Maj. Gen., U. S. A.
C. B. COMSTOCK,
Major of Engineers and Bvt. Brig. Gen., U. S. A.
CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

IMPROVEMENT OF THE MISSISSIPPI RIVER.

Remarks of Mr. James B. Eads before the House Committee on Commerce, made by special request of Hon. R. L. Gibson.

To estimate the merits of any system which may be suggested for the improvement of the Mississippi it is absolutely necessary to understand the causes of the phenomena presented by the river. Fortunately, the laws which control these are among the simplest and most easily understood of any of which we have knowledge. It is true that the different conditions existing at certain localities and during certain stages of the water so modify or complicate the action of these laws that their direct influence is obscured and sometimes seems doubtful. There is not, however, a single phenomenon presented by the river that is not capable of complete solution through the application of these laws.

The chief of these relates to the power of transportation of sedimentary matter by the stream. It may be stated briefly in the following propositions:

The sediment is carried in suspension in the water in proportion to the velocity of the current, the quantity carried per cubic foot of water by any given velocity being modified, however, by the depth of the stream.

The great mass of sedimentary matter which is transported to the sea by the river, constituting the *débris* of half a continent, is carried in suspension in the water and is not pushed or rolled along the bottom.

The quantity of sand, &c., suspended in the stream has direct relation to the velocity of the current. The changes of velocity which are continually occurring through the whole length of the river—at one point being retarded and at another accelerated—are consequently the chief cause, through the action of this law, of the caving banks, the shifting sand-bars, and the devastating floods to which its alluvial lands are subjected.

The velocity of current is the result of the inclination of the surface slope of the water. The angle which this slope forms with the horizon, or the fall per mile, indicates the intensity of the force of gravity applied to overcome the resistance to the flow of the water. The resistance is mainly due to the friction of the water in passing through the bed of the river. The flow is also retarded by the bends and the inequalities in the width and depth of the river-bed. As the resistance is increased at one or another locality, from any or all of these causes, the

slope of the surface is increased to meet the demand at that place for more force (or gravity) by which the requisite velocity can be maintained and the stream be enabled to carry forward to the sea without loss its suspended burden of earthy matter.

This alteration of slope is accomplished by the action of this law, for if the necessary velocity be reduced by the resistance a deposition of sediment at once ensues, by which the bed is raised and the slope is thus increased until the normal or requisite velocity is obtained, after which further deposit ceases.

It is a remarkable fact that the average current of the entire river, including the Missouri, (for I am speaking of the main trunk of the great water system of the valley of the Mississippi,) is very uniform in flood-time, from one end of the river to the other, although the inclination of its surface slope is doubled and quadrupled, and indeed is ten times greater in the upper than in the lower part of the river. These surface slopes are unquestionably regulated by the river itself wherever it traverses an alluvial bed throughout its course, and they are so regulated that the velocity is suited to discharge into the Gulf the average quantity of sediment that is annually poured into its trunk. That the amount of this annually discharged must be almost identical with the average quantity annually received from its various tributaries (supposing its banks are leveed and overflow prevented) is evident, for if it discharged a less quantity than it received, the remainder would inevitably reduce the average size of its channel. If it discharged a greater quantity than it received, the excess must be scoured out of the bed, and this would enlarge the average size of its channel. When uncontrolled and permitted to overflow its alluvial banks, the case is somewhat different, because a considerable part of the sediment is then borne over the banks and deposited, in flood-time, on the overflowed lands.

The slope of the river in the last fifty or sixty miles of its course, near the Gulf, is but little more than one inch to the mile, but, proceeding up stream, the slope becomes steeper and steeper. It is three or four inches to the mile at Vicksburgh and five or six at Cairo, while at Omaha it is nearly twelve inches.

The *quantity* of water flowing in the river is found to have an inverse ratio to the slope of its surface. In the upper portions of the streams the slopes become steeper as the quantity of water flowing becomes less. This relation between the volume and slope of the river is particularly marked in every one of the multitude of outlets by which the river finds its way into the Gulf. At the head of the passes it is especially noticeable. Here each separate portion of the stream that is carried through the South Pass, the Southwest Pass, and Pass à l'Outre at once assumes a steeper slope than the main stream, because the volume of water in each is so much less. As the volumes flowing through these are unequal, each has a different surface slope, which is unquestionably formed by the river itself and which is suited to its needs.

A glance at the map will show that these slopes are all different, because the length of each pass is different from that of its fellow. As they all start from the level of the river at the head of the passes and end in another level common to all of them, namely, the Gulf of Mexico, they must necessarily have different slopes. The South Pass, being twelve miles long, has a fall per mile nearly three times as great as that of the main river immediately above it, while that of Southwest Pass is about twice as great.

These phenomena teach us that inasmuch as the river itself is the architect of its delta, and has formed these different passes and the main stream, so that the current velocity in each is just suited to transport its sedimentary burden to the sea, without material loss or addition thereto, there must of necessity be a direct relation between the velocity of the stream and its transporting power. If this be so, it follows that when the current is charged with its normal load or quantity of sediment, it will have no power to carry more than that quantity unless its current be increased. The converse of the proposition must be equally true, namely, that if we check its current it will be unable to sustain the whole burden with which it is at that time charged.

Now if these simple facts are applied in explanation of the causes which have formed the sand-bars and shoals obstructing the navigation of the river, they will show why they are invariably located where the river is widest, and why they are invariably absent where the channel is narrow. A moment's reflection upon the effect produced by a rise in the river will show why these are formed in the wide parts of its bed. Suppose a wave constituting a rise of ten feet is moving down the river; the effect of the first narrow portion of the river through which it passes will be to accelerate the current. This acceleration gives a greater carrying capacity to the water, and it at once attacks the bottom and banks of the narrow channel for more sediment. Emerging from this narrow part, with high velocity and full charge of sediment, into one of the wider or larger parts of the river, the water is unable to maintain the same velocity or to sustain the load with which it is charged, and the excess of its burden is here dropped in the effort of the river to restore the equilibrium between the velocity and the load. The bottom is thus elevated until a

steeper surface slope is produced, and the result is the creation of a natural dam or shoal throughout this expanse. The water relieved of part of its burden then again enters a narrower part of the river, and here scours up an additional load because it has a higher velocity imparted to it. In this way it passes on through the wide and narrow stretches of the river, having its velocity continually changing; and as a result it is continually cutting away the banks in one place to deposit its spoils in another. Now, is it not evident that when the water is charged with its full burden of sediment or that which is due to its velocity it will neither take up an additional load nor drop that which it has so long as its current be maintained without alteration? I have measured the channel depth in every bend of the river from Cairo to New Orleans and do not remember to have found less than twenty feet at low water in any one of them. If the wide places where the shoals exist be reduced in width to that of the bends, there is no reason why a continuous twenty-feet channel in low water would not result throughout the entire distance from Cairo to the Gulf.

By bringing the river channel to an approximately uniform width a uniform depth of channel must result. A channel of uniform width will not be subject to these constant alterations of current velocity, and the caving of the banks must necessarily cease. A uniform width of the river, therefore, implies a uniform depth, and this means at least twenty feet of water at all seasons of the year through eleven hundred miles of navigation to the sea. But a uniform width of channel means more than this; it means the prevention of caving banks and of the loss of valuable farms and improvements thereon. It means far more than this; it implies the reclamation and protection of thirty-seven thousand square miles of the richest alluvial territory on the face of the earth, for a uniformity of channel width also implies a lower flood-line, which is equivalent to lifting this vast and fertile area above the level and beyond the devastation of the annual floods of the river. How can this be accomplished? In speaking of the slopes in the river reference is made only to those which exist in flood-time. The fact that the slope is increased in proportion as the volume is diminished is an evidence that the friction of the bed of the stream bears a direct relation to the velocity of the current, and that if the friction of the bed of the stream be increased it will be necessary to increase its surface slope to give it that velocity which it must have to carry in suspension its burden of sediment.

This is most readily illustrated by taking two pipes, one of which is one foot in diameter and the other four feet. To produce the same velocity in water flowing through these two pipes, to the smaller one must be given a greater inclination; because the proportion of frictional surface to volume of water is much greater in it than in the larger one. For, although the larger one has four times the frictional surface or circumference in contact with the water, it will contain sixteen times as much water as the smaller one. Now, by comparing the frictional surface which retards the flow of the water through its narrow channel with that which retards its flow over the wide shoals, it will be perceived that the area of frictional surface is much greater on the shoals than in the narrow channels; hence at each shoal the surface slope will be found to be steeper than that in the narrow channels, and as each shoal is removed by contracting its width, the extra steepness of slope is likewise destroyed at these places, and as the surface slope is the flood-line, the height of the flood is lessened just so much by the reduction of each shoal. The aggregate of these reductions would materially lower the flood-line throughout the river above them and in the localities where they are made, and would certainly lower this line several feet from Red River to Cairo.

Again, as the slope of the river is increased in proportion as the volume of water is lessened, it is evident that if the river be divided into two channels by an island, the surface slope in these two channels must be steeper than the surface slope of the adjacent stream where it flows in a single channel. Suppose this extra slope to be three inches to the mile, which is not an unreasonable supposition, and the double channel to be four miles long; it is plain that if one channel be closed the other will be enlarged by the river, and a lowering of the surface slope equal to twelve inches would ultimately result in the flood-line throughout the portion of the river above such island.

The rise of the river at Cairo is nearly fifty-two feet above extreme low water. The correction of the shoals and of the island chutes below Cairo would possibly lower the flood-line at Cairo six or eight feet. If it were lowered ten feet the necessity of levees would not exist at that point. Any further reduction in the flood-line which might be found necessary, after the correction of the river, could be obtained by one or two or possibly three judicious cut-offs somewhere above the mouth of Red River. The effect of each cut-off would be to lower the flood-line throughout the entire alluvial region above it.

This system of river correction is not novel; it has been practiced with signal success through some of the alluvial districts of the Rhine, above Holland, where overflows were not infrequent and where levees had long existed. By a judicious system of cut-offs, and the reduction of the river to an approximately uniform

width, the adjacent lands have not only been made safe from overflow without the use of levees, but a deepening of the navigable channel of the river of from six to seven feet was also accomplished at the same time.

The treatment of the Mississippi below Red River would be less expensive and would require to be different from that above, owing to the fact that the river receives accessions of water at various points above Red River by which its volume is increased, while below it the reverse occurs. A large portion of the water which should find its way to the ocean through the main trunk of the river escapes at Red River through Bayou Atchafalaya, and below through Bayou la Fourche, Bonuet Carré Crevasse, and several other outlets.

If it be borne in mind that one end of the river-slope or flood-line is unalterably fixed by the Gulf of Mexico, it will be seen that this slope cannot be increased in any part of the river without raising it higher up on the levees. Now, as a diminution of volume is inevitably followed by an increase of slope, it must result that the depletion of the main river by these outlets tends to steepen its flood-line, and thus necessitates higher levees. The closure of these outlets and the consequent enlargement of volume in the main river, must therefore produce the opposite effect. It is noticeable, however, that the temporary conditions necessary to deepen or to raise the bed of the river are precisely opposite to the permanent effects which follow, and this has misled many engineers into the error of mistaking the temporary effect for the permanent one.

Although a division of the river into two channels by an island causes a steeper slope in each of them than in the main river, yet the temporary effect produced by closing one of these will be to increase its slope still more, but this increased slope produces an accelerated current in the other channel which enlarges it until it becomes of the same capacity as the river-bed above and below the island. When this has been accomplished it will be found that not only has the temporarily increased slope through the island chute disappeared, but that the flatter slope of the main river below the island has been permanently extended up through the entire length of the island channel, and not only has the slope through it been reduced but it has been lowered in the river above. If this be so, it must follow that results both temporary and permanent, but precisely opposite in character, will certainly occur when a crevasse or outlet is made through which a portion of the whole volume is diverted from the main channel and seeks the sea by another route, because the conditions are then exactly reversed. The outlet is simply an island chute, the land between it and the main river constitutes an island, and its closure must inevitably be accompanied by the same temporary and permanent phenomena that have just been described.

Therefore the opening of a new outlet would necessarily be attended with phenomena precisely the reverse of those which attend the closure of one, or of an island chute. The outlet would necessarily drain off a portion of the water flowing above it. This would of course temporarily lower the surface above it, just as the closure of an existing outlet would temporarily elevate it above the outlet. The main river channel below the new outlet would be too large for the needs of the river when thus depleted and the current in that part would be more sluggish. Hence the water would be unable to hold its burden of sediment in suspension there, and the process of raising the bottom would be immediately commenced by the river. This would continue until, by the diminished size of the channel below the outlet, the river had acquired the increased slope necessary to restore the velocity required to transport its suspended load without further loss. It would then be found that the flood-line of the river above the outlet had been permanently raised, and this in time would extend throughout the whole length of its alluvial region above the outlet, and would inevitably require higher levees.

This is not mere theory, for just such results have occurred, and very startling ones, even as recently as within fifteen years, caused by Cubitt's crevasse, an outlet three and a half miles above the head of the passes, through which about 20 per cent. of the Mississippi River is escaping to-day. It is an undisputed fact that the bottom of the river above the head of the passes has been raised from ten to twelve feet, and its channel capacity at that locality has been diminished nearly one-fourth within a few years.

There can be no doubt of the entire feasibility of so correcting the Mississippi River from Cairo to the Gulf that a channel depth of twenty feet during the low-water seasons can be permanently secured throughout its entire course, and that the alluvial lands on each side of its waters can be made absolutely safe from overflow without levees by such correction. This can be accomplished for a sum entirely within the ability of the Government and one really insignificant when compared with the magnitude of the benefits which would flow from such improvement. UNTIL SUCH WORK IS ACCOMPLISHED AN ANNUAL EXPENDITURE FOR THE MAINTENANCE OF THE LEVEES IS IMPERATIVE.

VIEWS OF GENERAL BEAUREGARD.

NEW ORLEANS, *February* 7, 1878.

MY DEAR GENERAL: I am glad to hear that the sphere of the Levee Committee has been enlarged to include the improvements of the Mississippi River; for the two objects are co-ordinate with each other, and if executed simultaneously, according to a well-studied plan, may be accomplished with little more than the amount estimated for by the United States levee commission of 1874, to reclaim only the alluvial lands of the Mississippi River by a system of outlets and levees, regardless of the improvement of the navigation of that important stream, which penetrates into the interior of the great valley of the West and has become so indispensable to its constantly increasing commerce.

It is evident that no definite plan of levees and improvements of the river can be devised until a thorough hydrographic survey of it and its principal tributaries shall have been made. This survey is earnestly recommended by themselves in their report, by Humphreys & Abbot in their Physics and Hydraulics of the Mississippi River, by Major C. R. Suter in his able report on the improvement of the navigation of the Mississippi River, (Executive Document 10, part 7, Forty-third Congress, second session, Senate,) and by Hon. A. G. Warfield's report, (congressional documents, H. R. 494, Forty-fourth Congress, first session.)

While that survey will be in progress the old levees should be restored by the General Government to their *ante bellum* condition and their gaps effectually closed, for the States in which those levees are located are no longer able to take proper charge of them or to insure that co-operation which is indispensable to success.

Two plans of protection against the Mississippi River have been warmly advocated: one of levees and outlets, by Messrs. Humphreys & Abbot, and by the levee commission, without even a thought being expressed that this great navigable highway of half the continent might be so improved, with a part of the sum estimated for, as to secure a ship-channel from the mouth to Cairo, or perhaps Saint Louis, while lowering, possibly, the flood-line between those extreme points. Their plan consists in abstracting from the river and conducting by separate channels to the Gulf such a volume of the flood discharge as shall be sufficient to bring down the flood-level to a height easily under control by levees; thus assuming that a reduction of the volume of water in the channel will produce a permanent lowering of the flood-line, while an increase of volume will permanently elevate that line—which is disproved by each one of the passes and bayous leading from the river to the Gulf. (See J. B. Eads's review of report of United States levee commission, marked "C," page 23.)

With regard to closing up crevasses the levee commission says: "If we guard against these crevasses by raising and strengthening our levees, an elevation of the high-water mark exactly proportional to the increased volume will be sure to occur. To contain a quart of water a vessel must have exactly the requisite number of cubic inches, and a like principle applies with equal force to water in motion." As great a fallacy when applied to streams passing through alluvial soils as could have been uttered even by non-professional men, for the Mississippi River, especially, is doing nothing else but changing constantly its bed from Cairo to the Red River, a distance of eight hundred and twenty miles. Even in the second and fourth districts of this city we see that the river has shifted its bed at least half of its width in the last fifty years, the same at the Villeré plantation, eight miles below New Orleans, and at the English Turn, a few miles further down. The levee commission, regardless of existing facts, maintain that, "Very numerous soundings with lead, adapted to bring up samples of the bottom, were made by the Mississippi Delta survey (physical and hydrographical) throughout the whole region between Cairo and the Gulf. They showed conclusively that the real bed upon which rest the shifting sand-bars and mud-banks, made by local causes, is always found in a stratum or hard blue clay, quite unlike the present deposits of the river. It is similar to that forming the bed of the Atchafalaya at its efflux and, as is well known, resisting the action of the strong current almost like marble. Clearly, then, the bed of the Mississippi cannot yield, and if the velocity be increased sufficiently to compel an enlargement of the channel it must be made by an increased caving of the banks, an effect which it is not quite so agreeable to contemplate." To this statement Captain Eads has answered, I think very properly, (see C., p. 8:) "Blue clay is found in the bottom and banks of the Mississippi at various localities, from the head of its alluvial basin to the Gulf. The exposure of the various strata in its banks above low-water mark and the intersection of these strata in various artificial excavations, their rapid destruction by the river current where the main stream forsakes its own channel and carves out a new bed through one of its many characteristic 'cut-offs,' the penetration of several of these strata by the artesian well at New Orleans before it had reached a depth equal to the present bed of the river at that place, and through which strata the river has evidently cut its way, all prove that the ordinary blue clay of the river will not resist the incessant action of the current."

The plan proposed by Captain Eads to prevent overflows and improve the navigation of the Mississippi is as follows: (See accompanying article from the New Orleans Picayune, marked "A," which gives so good a synopsis of the captain's plan that I prefer it to anything I might write. I inclose you also an article from the Cincinnati Commercial, marked "B," which gives in full the captain's views, and which you may consult for further information.) I feel no hesitation in saying that of the two proposed plans I give the preference to Captain Eads's, for it is founded, in my opinion, on sounder engineering principles, and I think if judiciously carried out will not only remove the forty-three low-water bars below Cairo, on some of which there is only four and a half feet of water, but would doubtless lower the flood-level, to what extent I am not now prepared to state owing to the want of reliable data on which to base any calculation.

If you permit me I will suggest that Congress should appropriate the sum of $300,000 "for a thorough hydrographic survey of the Mississippi River and its principal tributaries, with a view to increasing the navigable depth, obviating the existing dangers due to sand-bars, snags, &c., and to lowering its flood-line, thereby making a levee system more practicable and less expensive." Also another sum, say $3,000,000, to allow Captain Eads, under the supervision of a commission of three or five engineers, to apply his plan of improvement in a section of the river of —— miles, above or below Memphis, where the bars may be worst. That experiment, which is worthy of the stated sum, would not only test the system, but furnish data to make a correct and reliable estimate of the cost for the protection of the alluvial basin from New Orleans to Cairo, after the hydrographic survey above referred to shall have been completed.

I remain, dear general, yours, most truly,

G. T. BEAUREGARD.

General R. L. GIBSON,
Member of Congress, Washington, D. C.